

## Editorials

### Halley's Comet and others: the bacterial star shells

The recent encounters by the spacecraft Vega and Giotto with Comet Halley led to results that in the main were unexpected. The comet had been said to be a 'dirty snowball', which if it had been true would not have been particularly interesting. Instead of possessing the 20–50% reflectivity of dirty snow, the comet turned out to be exceedingly dark with a reflectivity around 2%. Comet Halley is emitting both gas and dust at rates of the order of 10 tons per second, with the emission coming from small areas of the black surface. Water molecules are present in considerable quantity in the gas, making water a major constituent of the comet, as had been expected, although on the information so far published it cannot be said that water is overwhelmingly the major constituent. There must be important sources of carbonaceous molecules which have been detected in individual masses above 100 daltons, while there appears to be more of the OH radical than can be explained by  $\text{H}_2\text{O} \rightarrow \text{H} + \text{OH}$  alone.

The biggest surprise concerns the composition of the dust, which had been expected to be not much different from ordinary household dust which has a specific gravity of about 3. Much of the dust has turned out to be submicron particles composed largely of hydrogen, carbon, nitrogen and oxygen with densities that, like dried bacteria, are less than  $1 \text{ g cm}^{-3}$ .

While it was a great advantage for many experiments to visit the comet by spacecraft, other experiments could be done as well or better from the Earth. This is particularly the case when unexpected things happen. It was unexpected that heat radiation from the dust would be detectable in the wavelength range from 3 to 4 microns, which range is highly important for identifying the nature of organic material. The points for Figure 1 were obtained by D T Wickramasinghe and D A Allen using the Anglo-Australian Telescope sited in New South Wales, Australia. The large error bars near 3 microns are due to the circumstance that the Earth's atmosphere also emits radiation near 3 microns. While this is a disadvantage of terrestrial ground-based observations, the disadvantage was more than offset in this case through the use of a very large and accurate telescope, through the comet being observed from the southern hemisphere at the optimum point of its orbit, and through the ability of ground-based observers to make frequently repeated calibrations of their equipment. Thus one can have confidence that within the marked error bars these observations are correct, which is not something one can always say for observations made from space.

The curve of Figure 1 shows what a common bacterium such as *E. coli* would emit, if the bacteria were dry and heated to a temperature of 320 kelvin

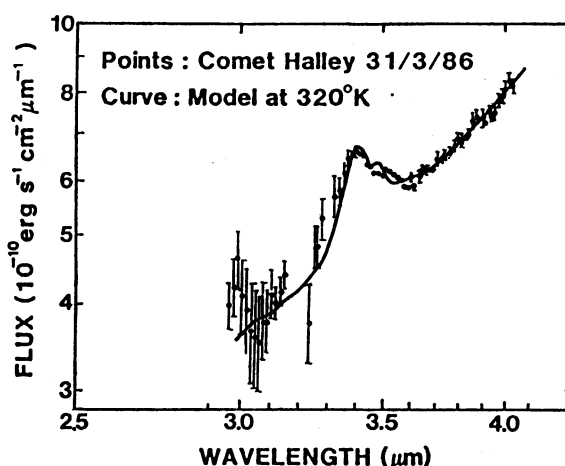


Figure 1. Points are observations of flux at various wavelengths made by D T Wickramasinghe and D A Allen of Comet Halley on 31 March 1986, the radiation coming from dust particles expelled by the comet. The curve is the expected emission if the dust particles were bacteria at a temperature of  $47^\circ\text{C}$ . (© D T Wickramasinghe, D A Allen, F Hoyle & N C Wickramasinghe)

( $47^\circ\text{C}$ ). (This is subject to a choice of a normalization factor which can only move the curve bodily up or down in the Figure.) The laboratory data for *E. coli* on which the curve depends are shown in the measured spectrum of Figure 2. The measure of agreement of the curve and points shown in Figure 1 demands that the material comprising the bulk of the cometary dust shall have an infrared transmittance curve agreeing with Figure 2 to an accuracy of one small square in the graticule of Figure 2, which condition must apply at all wavelengths over the entire range from about 3 microns to 4 microns. No material other than a bacterium has an infrared spectrum published in the literature meeting this condition.

In view of the recently determined carbonaceous nature of the bulk of the cometary dust, in view of the

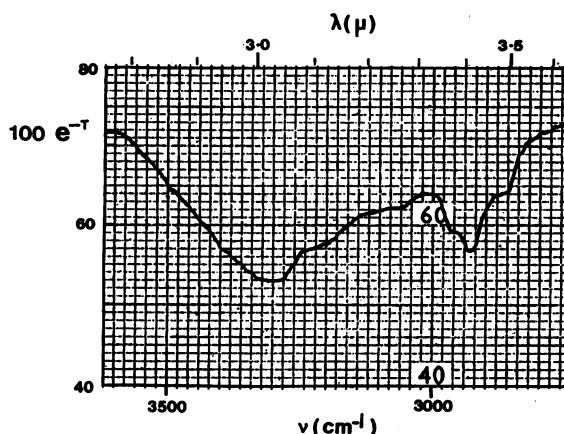


Figure 2. The measured transmittance of dry *E. coli*. The ordinate is the fraction of radiation at various wavelengths that penetrated the laboratory sample, expressed as a percent, the wavelength  $\lambda$  being in micrometres. (© S Al-Mufti, F Hoyle & N C Wickramasinghe)

sizes and densities being appropriate for particles of biological origin, and in view of the agreement to within a few percent of the curve and points of Figure 1, no person unchoked by prejudice would hesitate to consider very seriously the hypothesis that the bulk of the cometary particles really are bacteria. Especially, one might add, since the hypothesis immediately suggests an interesting explanation for the whole phenomenon of ejection of gas and dust from comets.

The surface of Comet Halley is not black because of absorption of sunlight in the immediate surface material, for if there were almost complete absorption close to the surface the surface material would necessarily be much hotter than it has been observed to be. To explain why the surface material is comparatively cool it is necessary that it be translucent – just the opposite state of affairs. Surfaces do not need to be absorbent in order to be exceedingly black. Materials reflect sunlight according to the extent to which their refractive indices are disordered on the scale of the wavelength of the light. Ice can be either very bright or very black according to whether or not it contains myriads of microscopic-sized air bubbles. Take a sample of bright bubbly ice, melt it to get the air bubbles out, and then refreeze and you have black ice. We can therefore conclude that the surface material of Comet Halley is not disordered with respect to refractive index. If it has porosity, as may well be the case, the pores must be systematically arranged as within a silica gel, not randomly placed as with the air bubbles in bright ice.

It is common for materials that are translucent at one waveband to be opaque (i.e. absorbent) at other wavebands. If cometary surface material is highly translucent at optical wavelengths but highly absorbent at infrared wavelengths around 10 microns, then the surface layer, which might be several metres thick, would act to produce a strong greenhouse effect. Energy from sunlight would go in, to be eventually absorbed at depth, say at depths of 10 to 20 metres as is the case for black ice, but once converted to heat there would be an impediment to the heat escaping back out into space. The energy from the sun would thus become stored, raising the temperature of subsurface material.

Rising temperature could produce melting, with ensuing chemical reactions then occurring in the subsurface material, but except on the unlikely supposition that the material is explosive, non-biological chemistry would be a pretty mild affair. Biochemical reactions depending on enzymes are, on the other hand, millions of times faster than ordinary reactions. Comet Halley has been found to rotate in a time exceeding 50 hours, and a bacterial culture that is permitted to grow for an interval as long as this can do a great deal, especially if there is a gaseous output from the enzymic reactions, as is commonly the case. Gas accumulating to sufficient pressure would lead to explosive outbursts from below, penetrating through the surface material like leaks from a water main, causing evaporating liquids and suspended bacteria to be spurted out into space, which is exactly what can be seen from observation to happen.

The comet Schwassmann-Wachmann I moves, not in the usual highly elliptic form of cometary orbit, but in a nearly circular orbit with radius a little larger than Jupiter's orbit. About once in 15 years there is a violent outburst comparable in scale to

Comet Halley. Because of the low intensity of sunlight at and beyond Jupiter's distance from the Sun, there is no possibility that the outbursts of Schwassmann-Wachmann I can be due to ordinary thermal evaporation such as is assumed by protagonists of the dirty snowball model. Provided, however, that the effect of sunlight is sufficient for a bacterial reaction to 'go' then, even at a gentle rate of production, gas would still accumulate to the point of explosive outburst. The case of Schwassmann-Wachmann I has always given a clear demonstration that the dirty snowball model must be wrong, but it fits a bacterial model without difficulty.

Quite apart from the significance of Figures 1 and 2 in bringing the bacterial model essentially to the point of proof, the discovery that comets emit of the order of 10 tons per second of organic dust is sufficient to open the question of a possible pathogenic relation between comets and the Earth. We have no really satisfactory explanation for why patterns of disease change over the centuries, and for why in our day new diseases and new variants of old diseases are perpetually appearing. There is also much difficulty in attributing the spread of diseases to person-to-person transmission.

Figure 3 shows notifications of pertussis in England and Wales from 1940 to 1982. If the old density of susceptibles theory for the 3.5 year periodicity of this disease had been correct, the general introduction of an effective vaccine in 1957 or thereabouts should so have reduced the density of susceptibles that the periodicity became shifted markedly from 3.5 years, or even destroyed altogether.

What the vaccine actually did was to reduce by a considerable factor the number of victims without changing the periodicity at all. Evidence of this kind, of which there is much, is sufficient, or should be, to give one a sense of disquiet over conventional theories, and to encourage a search for alternative ideas.

The undisturbed periodicity of Figure 3 suggests rather insistently that a supply of the pertussis bacterium is injected into the human community every 3.5 years or so in some way. If one has in mind the possibility of a cometary connection, the culprit can hardly fail to be Comet Encke.

It is definite that small particles emitted from Comet Encke enter the Earth's atmosphere. There are particles with sizes of the order of 1 mm, visible as

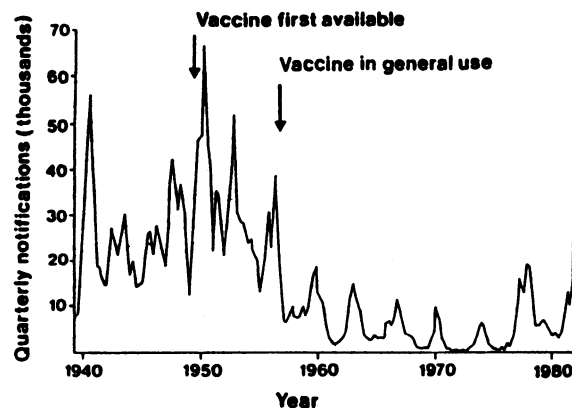


Figure 3. Whooping cough notifications in England and Wales 1940–1982. (Reproduced with kind permission from Hoyle F, Wickramasinghe C: *Living Comets*. University College Cardiff Press, 1985)

meteors, forming meteor showers, the  $\beta$ -Taurids from 23 June to 7 July and the Taurids from 20 October to 25 November, these being the times in the year when the Earth crosses streams of particles from Comet Encke. Since the Earth misses the path of Comet Encke itself, only particles ejected from the comet at explosive speeds can reach the Earth, which is to say only particles that have had their orbits appreciably changed by the ejection process can reach the Earth. In particular, it is essential that particles should go at ejection into orbits with much smaller inclinations to the Earth's orbit than the  $12^\circ$  inclination of the comet itself, a condition that requires the direction of explosive ejection to be nearly perpendicular to the plane of Comet Encke's orbit.

The relevance of this bit of geometry is that particles reaching the Earth from Comet Encke tend to have more energy per unit mass than the material of the comet, and so take a bit longer to go around the Sun. The orbital period of Comet Encke is 3.3 years, not the 3.5 years that best fits the pertussis data. But when the extra energy acquired by particles reaching the Earth is allowed for, it turns out that the 3.3 years of the comet itself is indeed lengthened to about 3.5 years. This detail does almost more than anything else to convince me that the pertussis bacterium really does come from Comet Encke. At first sight the cometary period looks a little wrong, but when more accuracy is used with greater insight the period comes out just right.

If these considerations are correct, there would be a strong motive to send a spacecraft to Comet Encke.

The comet is reachable at all times. Even at its greatest distance from the Sun it is nearer to us than Jupiter. At its greatest distance from the Sun, speeds are low, about a tenth of the speeds involved in the recent encounter with Comet Halley. Partly for this reason and partly because Encke ejects dust less copiously than Halley, there should be little danger from dust bombardment in taking a space vehicle close to Encke. I do not think it would go much, if at all, outside presentday technology to make an actual landing on the comet, to scoop up samples of material and then to return the samples to Earth. If the pertussis bacterium comes from Encke, then so very likely do other pathogens, including viruses. Encke was at perihelion, and so fairly close to the Earth, in 1918, 1947, 1957, 1967 and 1977, all years in which the influenza virus is known to have undergone major shifts.

The possibility that pathogens might be recovered from their source(s) raises the interesting idea that, if pathogens were recovered ahead of their arrival on the Earth, the way would be opened for preparing preventive vaccines ahead of their requirement. Indeed, the whole of preventive medicine would be revolutionized. For the first time in human history the way may be opening for us to protect ourselves against the ravages of disease. Instead of passively waiting for diseases to strike, and then attempting to moderate their impact as much as possible, it may well be possible to attack diseases at their real sources.

Fred Hoyle

## Psychopaths and their treatment

Psychopathy is one of the most distressing of the personality disorders and poses perhaps the greatest therapeutic challenge to psychiatry and allied disciplines. Clinical definitions have barely changed over the last two hundred years and doubts have been expressed about whether it constitutes a real disorder. The capacity to classify it, understand its aetiology, predict its course or to treat its victims has advanced correspondingly little. Paradoxically, as is not uncommon in medicine, advances in treatment, although small, have outstripped growth in other areas of knowledge. Stuart Whiteley's account, in this issue (p 721), of his development of a treatment approach for people who have been called psychopaths, hardly does justice to the consequent difficulties he has faced and his years of effort in the field.

One of the earliest recorded clinical definitions of psychopathy is that of Phillippe Pinel in 1801<sup>1</sup>. He noted the absence of appreciable alteration in the intellectual functions, perceptions, judgments, imagination and memory, but the presence of blind impulses to violence and a pronounced disorder of emotional functions. The term has been used in a legal sense too and, against advice, it was retained in

the Mental Health Act 1983, where the possibility of associated intellectual impairment is allowed. One of the more recent definitions<sup>2</sup> is less progressive than Pinel's. It fails to identify any primary characteristics of the individual and merely specifies a lower age limit of 18 and the presence of a selection from a range of antisocial behaviours, which are not due to mental retardation, schizophrenia or manic episodes. Thus we can be reassured about what is not psychopathy, but tautological statements of what psychopathy is persist. Perhaps wisely, Stuart Whiteley now usually refers to his patients as personality disordered rather than psychopathic, as used to be his practice<sup>3</sup>.

It is not surprising that, from such an uncertain baseline, psychiatrists have found it hard to agree on the diagnosis for any particular individual; inter-rater reliability is low. Furthermore, it has proved as hard to conceptualize the disturbance as to describe the presentation of patients. There are those who would construe the psychopath in much the same way as the subnormal individual – disabled because he falls at the extreme end of a normal distribution of characteristics, rather than because he has a discrete disorder<sup>4</sup>. Some<sup>5</sup> view the spectrum differently and regard psychopathy almost as a *forme fruste* of psychosis, while others have come close to this position but then called the disorder they describe by a different name, such as borderline<sup>6</sup>. Lewis<sup>7</sup> summarizes the